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THURSDAY EVENING, JAN, 15, 1880.

The Exterior Planets.

Mars—Jupiter—Saturn—Uranus—Neptune—Asteroids.

Lecture Delivered by A. S. Hershey, esq., Before the Star Club.

The exterior planets are so-called because they revolve above the sun in orbits exterior to that of the Earth. They are sometimes called superior planets for the same reason. At present the heavens present a fine opportunity for the study of these brilliant orbs. In the early part of the evening three most prominent of the superior planets may be seen following each other through the heavens, with Jupiter in the lead, Saturn with his rings close upon him, while burning Mars brings up the rear. What a grand opportunity for the astronomer! If he tires of Jupiter and his moons, that are ever changing in position, with their transits across the disk of the planet and their constantly recurring eclipses, he can direct his instrument to Saturn with his rings and satellites, or view the landscapes of Mars.

Mars.

Mars was named after one of the ancient deities who was the god of war. No doubt the astronomer gave the planet this name from its ruddy appearance. The Jews gave it the name of "blazing" from its red color. Mars does not always appear to us of the same size; at conjunction it is much smaller than when in opposition; this is owing to the difference in the planet's distance from us. When at the point nearest to us in its orbit its diameter is more than seven times greater than when at its most distant point.

It revolves around the sun at a mean distance of 140,000,000 miles. This orbit, like those of all the planets, as Kepler has demonstrated, is in the form of an ellipse, and in consequence thereof the planet is nearer the sun in some parts of its orbit than in others. The orbit of Mars is flattened out considerably, and it has been estimated that its perihelion distance is twenty-six million miles nearer the sun than its aphelion distance. The Earth's orbit varies only three million miles, thus making the variation of the orbit of Mars about nine times as great as that of the Earth. Mars was the planet upon which Kepler decided to make his observations on the motion and orbits of the planets. Finally, after experimenting and watching the planet for seventeen long years, he announced his grand discovery, the three great laws of motion.

Mars sweeps around the sun in its orbit with an average velocity of fifteen miles per second, which is three miles less per second than the rate at which we, upon the Earth, are hurried through space. It makes a revolution on its axis in 24 hours and 40 minutes. This makes the Martial day but forty minutes longer than our own, and since its year contains 668 days, this would be equal to 687 terrestial days, or nearly two of our years.

The diameter of Mars is about 5,000 miles and the circumference, as a matter of course, is 15,708 miles. The volume of Mars has been estimated to be one-fourth that of the Earth, and its density only one-half; hence its mass or weight is only one-eighth as great as that of the Earth's, or 758 quintillions of tons.

The light and heat of the Sun at this planet is less than one-fourth that which we enjoy, being twice our distance from the Sun. Its axis is inclined 28.70° to the place of its orbit; therefore seasons can not differ very much from ours, as the Earth's axis is inclined 23½ degrees. Its days are nearly equal to ours, but there must be a greater change in the length of night and day in the different seasons of the year, owing to its greater angle of inclination. The seasons of Mars must be about twice as long as ours, because the year is equal to two terrestial years, Shadows or dark bodies are often seen passing over its surface. These are supposed to be clouds passing through the atmosphere.

Until quite recently Mars was supposed to be without moons, but in August, 1877, Prof. Hall, of the naval observatory at Washington, discovered two satellites revolving around the planet; the outer one, at a distance of about 12,000 miles, making its revolution in thirty hours and eighteen minutes, traveling almost as rapidly as the planet on its axis, so that when once in sight to an inhabitant on the planet it could be seen for a long time before it sets. The other is but 3,600 miles from the surface of the planet. This is only 600 miles farther than the distance from New York to San Francisco. There is one peculiarity about this satellite. As it passes round the planet, in 7 hours and 40 minutes, it will be seen that it travels faster than Mars rotates on its axis, and in it course overtakes an object on the planet, and since it travels in the same direction, it passes by the object and sinks out of sight in the east, and rises in the west. This rapid motion of the moon causes also, to the inhabitant of Mars, an apparent motion of two moons in opposite directions. As we look at Mars in the heavens he appears to us only as a red star; but under the telescope he presents a novel appearance, and astronomers claim that they have discovered land and water, and also "ice-caps" at the poles, which are supposed, like our own polar regions, to be covered with perpetual snow. These spots grow larger and become smaller, decreasing with the return of summer and increasing with the return of winter. [Illustrated by maps and diagrams.]

We all know that there is three times as much water as land surface on our globe; on Mars this order is reversed and there is three *times as much land as water*. Prof. Proctor says the older a planet gets the less water will be visible, that it passes into the body of the planet; and as proof of this he cites Mercury and Venus, which are supposed to have very little water.

Mars, like the Earth, is not a perfect sphere, but is somewhat flattend at the poles, caused no doubt by its rapid revolution on its axis, which tends to bulge it out along the line of the equator. It has slight phases which proves that the planet like the Earth is an opaque body, and shines with borrowed light. [The gibbous phase of the planet and its apparent retrograde motion were illustrated by diagrams].

Jupiter.

Passing outward from the Sun, the next planet in our course is Jupiter, named after the king of the gods. Jupiter is the largest planet of the solar system. He can easily be distinguished from the other planets and the fixed stars around, from his great brilliancy. This was one of the earliest discovered planets, and was credited by the ancients with extraordinary power and influence in mundane affairs.

The average distance of Jupiter from the Sun is 475,000,000. The orbit of this planet has much less eccentricity than these of the planets nearer the Sun; a wise provision of nature, because if his orbit were less circular, the influence of the Sun would be insufficient to hold him in it. If we look at Jupiter we find that he changes his place but little with reference to the fixed stars. We observe that other planets move over the surface of the heavens, overtake Jupiter and pass him by, while he apparently moves slowly along. Yet he goes at the rate of 500 miles a minute—or from Philadelphia to Pittsburgh and back again in less than a minute; his year is equal to twelve of our years, and he passes through one sign of the zodiac each year. While he moves slowly in his orbit on his axis he revolves very rapidly, completing a revolution in ten hours, any object on the equator revolving with a velocity of 467 miles per minute against the Earth's seventeen miles per minute, This must produce a powerful centrifugal force, which must greatly diminish the weight of a body on the surface near the equator.

The diameter of Jupiter is about 88,000 miles, or one-tenth of the Sun's diameter. Its volume is one thousand four hundred times as great as the Earth's, and much greater than all the other planets put together. If it should take the place of the Moon in the heavens, it would appear to us one thousand two hundred times as large as our full moon, giving us light enough to dispense with gas during full moon. Its density is only one-fourth that of the Earth.

The equatorial diameter exceeds its polar diameter by about 5,000 miles, which is equal to the diameter of Mars. This is caused by its rapid motion on its axis, which must have continued since the creation of the planet.

As the inclination of the axis of Jupitor is slight, it follows that days and nights are almost equal length throughont the year—five hours from sunrise to sunset. With so little inclination of the axis there can be little change of seasons—there must be perpetual summer at the equator, continuous springs in the temperate zones, and winter reigns supreme in the polar regions.

The heat and light of Jupiter are only one-twenty-seventh of that which we receive; so that unless there is some other means unknown to us, compensating for the loss of heat and light, it would not be a very inviting place of residence for man. But if the Jovian citizen does not enjoy our bright and genial sunshine he can boast of a magnificent night. In five hours he can see all the constellations that pass over our heads during the night, besides witnessing four moons with their divers phases in different parts of the heavens. These moons were first discovered by Galileo in the year 1610 through the telescope, although there are instances on record where they have been seen with the naked eye. They revolve at the following distances from Jupiter: No. 1—270,000 miles; No. 2—425,000 miles; No. 3—678,000 miles, and No. 4—1,200,000 miles. The diameter of the smallest is 2,100 miles and of the largest 3,500 miles. [Illustrated by a diagram showing the eclipses, occultations and transits of the moons.] They must revolve with great rapidity to overcome the attraction of Jupiter upon them, otherwise they would be drawn in to the planet. The nearest moon goes through all its phases in one and three-fourth days, and the most distant in less than twenty days. If Jupiter is inhabited, its citizens can witness during a Jovian year 4,500 lunar eclipses and about the same number of solar eclipses.

Velocity of Light Discovered.

There is a circumstance worth mentioning in connection with the moons of Jupiter. It was observed that the eclipses of Jupiter's satellites, which occurred while the Earth and planet were at their least distance from each other, always came on sooner than the time predicted by the tables; while on the contrary, those those which took place when the planets were most remote from each other occurred later than the computed time. Roemer, a Danish astronomer, finally solved the problem; he found that these irregularities arose from the fact that light traveled through space with a finite and measurable velocity. When Jupiter and the Earth are at their least distance from each other, the stream of light flowing from the satellite of the planet traverses a shorter space to reach the eye of the observer on the Earth by nearly 200,000,000 of miles than when the planets are more remote from each other. In case this stream of light is in any way cut off, it will run out sooner in the first than in the second position, by the time required to pass over the diameter of the Earth's orbit. The stream of light is actually shorter by 200,000,000 miles in the first than in the second position. Now, the statellites of Jupiter receive their light from the Sun; they reflect this light to the Earth, and when Jupiter is interposed between them and their source of light, they are eclipsed—their light is cut off. And when the stream of light starting from them, at the instant the supply is cut off, shall have run out, then and not till then does the satellite become invisible. By this means light was found to travel the entire diameter of the earth's orbit or 190,000,000 miles in about 16 minutes, giving a velocity of 12,000,000 per minute.

The telescope reveals to the observer a number of belts upon the surface of Jupiter of different colors, constantly varying in size, but all seeming to take a parallel course across the equatorial regions. [Diagram.] The dark belts are supposed by some to be large masses of clouds, and the bright belts are mere fissures, laying bare the surface below; and the parallel appearance of the belts is supposed to be caused by equatorial winds, similar to our trade winds. Some two years ago a large red spot was noticed on Jupiter, which has been gradually increasing in size. [Position and size indicated in diagram.]

Saturn.

Leaving Jupiter and continuing our outward course, we next strike Saturn, the most distant world known to the ancients, and in many respects the most remarkable planet of the solar system. It has not only double the number of satellites of Jupiter, but has, in addition, a number of rings encircling it, some shining with a golden light and others transparent. This planet performs its revolution round the sun in 29½ years, at a mean distance of 872,000,000 miles in an orbit considerably flattened.

The diameter of Saturn is about 68,650 miles, or about nine times that of the Earth, and it would require 750 globes like the Earth to make a bulk equal to Saturn. It moves through space at the rate of 21,000 miles per hour, and yet, as we look at it night after night, we can scarcely detect any change of place. The Saturnian year comprises about 2,500 Saturnian days, and is equal to about thirty of our years.

In 1793, Sir William Herschel saw a quintuple belt, and by frequent examination of this belt he found Saturn's rotation a little over 10 hours, making Saturn's day about 10 hours. He also noticed that the polar regions changed their appearance as they were turned toward or from the Sun, which, as in Mars, might be owing to snow at the poles. Saturn has eight moons, all varying in size and distance from their primary, and their eclipses and occultations are somewhat similar to those of Jupiter.

Galileo first noticed something peculiar in the shape of Saturn. Through his imperfect telescope, it seemed as though several smaller planets had nestled close to each side of old Saturn, and he first thought Saturn was three-fold; but as the planet approached the equinoxes, this strange appearance vanished altogether. This perplexed Galileo very much, and he died before the mystery was solved. The rings, seen again at a later period, appeared as though they were handles attached to the planet, but for what purpose no one knew. This appearance was due to a break in the luminous rings made by the projected shadow of the planet The plane of the rings is inclined twenty-eight degrees to the ecliptic. In its revolution round the Sun, owing to this inclination, the ring is sometimes observed as a broad ellipse, at other times as a straight line, barely discernable with the most powerful telescope. The rings are three in number, about one mile in thickness, and of equal breadth surrounding the planet at the equator. The exterior ring is separated from the middle ring by a distinct break, while the interior is joined to the middle one. The exterior ring is of a grayish tint, the middle one is the most brilliant and more luminous than Saturn himself. The ring is dusky and has a purplish tint. The exterior and middle rings are both opaque and cast on the surface of the planet a distinct shadow, while the interior one is so transparent that it appears upon the globe of Saturn as a dark band through which the surface is readily seen. [Diagram.]

Proctor, in speaking of Saturn and his rings, said we had in them an illustration of the nebular hypothesis in miniature, and that probably these rings would at some future time change into globular form and add three more to the number of satellites of this planet.

Uranus.

Saturn was for a long time supposed to be the most distant of the planets, and it was not until 1781, on the 13th day of March, that Sir William Herschel discovered a new planet and named it after Uranus, the most ancient of the gods. Uranus revolves around the sun at a mean distance of 1,754,000,000 miles. Its year exceeds 84 of ours. Its diameter is about 33,000 miles, and is about 61 times as large as the Earih.

This planet has four satellites, which differ in their motion from the other members of our system in this respect, that instead of revolving around the planet from west to east, the order is reversed and they move from *east to west*. Another peculiarity about these moons is, that their orbits are inclined almost at right angles with that of the planet's orbit.

Neptune.

We now come to the last and most distant planet of the solar system. Neptune, the god of the sea. Astronomers in observing Uranus, noticed slight perturbations, and came to the conclusion that there must be a planet in existence beyond Uranus that had some influence upon him. Mr. Adams, of England, and Leverrier, of France, calculated the position of the planet, which result was announced to the Academy of Science, at Paris, in the summer of 1846. Very little is known of this planet, but it has been ascertained that it revolves around the Sun in a period of 164 years at a distance of about three billion miles. Its diameter is given as 39,000 miles, its bulk 121 times that of the Earth. No spots can be detected on his disk, and therefore we know nothing about his time of rotation on the inclination of his axis. One satellite has been discovered, and like the moons of Uranus, it has a retrograde motion.

The Asteroids.

Planets have another division, besides that into interior and exterior, known as major aud minor planets, the latter being sometimes called Asteroids. Bode's law would make the distance of any planet from the Sun about double that of the next interior, and half that of the first exterior one. But this law seems to fail, leaving a chasm between Mars and Jupiter, which was therefore supposed for many years to contain a planet, and which finally proved to be occupied by a very large number of planetoids. Piazzi discovered the small planet Ceres on Jan. 1, 1801, the first night of the present century. This discovery was soon followed by others, until the number is now about 200. Leverrier thinks it possible that there are over 150,000 in all. These planets are all very small, Pallas being the largest, with a diameter of 600 miles, while some could be covered over with a country village. They all revolve around the Sun in regular orbits comprising a zone of 100,000,000 miles in width. Their orbits are variously inclined to the ecliptic; Massilius is inclined only 41 minutes while the inclination of Pallas is 340.

The true theory of these bodies is unknown, and a great many astronomers have speculated as to their origin. One theory is that at some remote period a planet circled around the Sun, and by some great force was rent asunder and its fragments hurled into space. This may account for the great angle of inclination of Pallas to the ecliptic. The explosion may have forced it far out of the angle of inclination of the planet of which it formed a part. Another theory is that of the nebular hypothesis, that nebulous matter revolved in the orbits of the minor planets for ages, and that it gradually formed itself into these small bodies, and that these bodies will eventually group themselves together and form a large planet like the others of the solar system.

Conclusion.

Whether or not any of these planets are inhabited is a matter for speculation. This will for ever remain a mystery to us. But it is not very likely that the Earth alone, which forms so small a part of the solar system, should be the abode of life. It has been well said, that it is altogether probable, that an all-wise God has created beings, and peopled every planet with intelligent creatures provided with organs suitable for the condition of each.

Proctor thinks that the elements and conditions of material and life are very much the same throughout the solar system, that Mars perhaps would be the only planet upon which life such as we know could he possible, and that the other planets are gradually undergoing changes which will eventually fit them for the habitation of man.